Lawrence Livermore National Laboratory

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Laser Science & Technology

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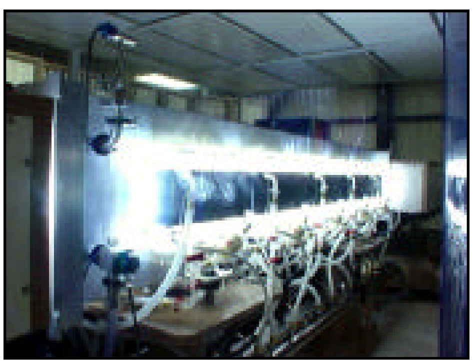
The HELSTF Heat-Capacity Laser Successfully Demonstrates 10-kW Output

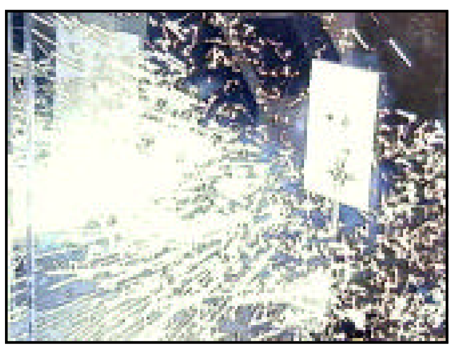
Under the support of the U.S. Army's Space and Missile Defense Command, and in collaboration with industrial partners (Raytheon, Litton Airtron, and others), we are developing high-average-power (100-kW class), diode-pumped solid-state, heat-capacity laser technology for applications in tactical short-range air defense missions. The ultimate vision is an electrically powered, diode-pumped, solid-state weapon that can be deployed on a hybrid electric vehicle. To establish a solid technical basis for the heat-capacity laser operation and risk reduction, we built a flashlamp-pumped Nd:glass laser prototype. In earlier work, a 3-disk heat-capacity laser amplifier module was successfully operated at 10 Hz with an output of 140 J/pulse. We have recently completed construction of a 10-kW prototype (9-disk Nd:glass amplifier pumped by flashlamps) to be installed in the Army's High Energy Laser Strategic Test Facility (HELSTF). The photo below shows the 9-disk heat-capacity amplifier under testing.



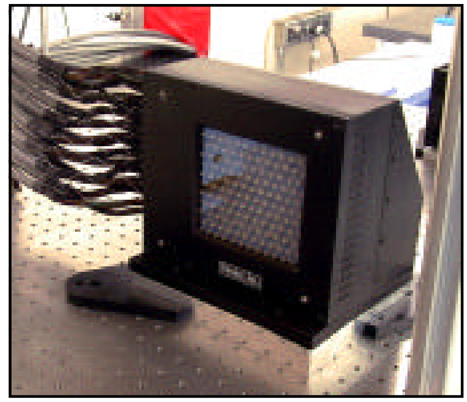
This 9-disk module is designed to have 10-kW average output power and deliver laser pulses with beam quality <3× diffraction-limited and energy of 500 J/pulse at 20 Hz for 10-second bursts. The laser amplifier is now fully operational for pulse repetition operation using testbed power supplies.

During the past month, the 9-slab amplifier was operated using a stable resonator with an ouput coupling of 29%. In the initial testing we successfully achieved an output power exceeding 10 kW for a burst of 100 pulses. The average pulse energy was 558 J with a pulse repetition frequency of 18.5 Hz. Experiments are also under way to measure gain uniformity and wavefront distortion to characterize a deformable mirror system to meet system requirements delineated to the HELSTF.

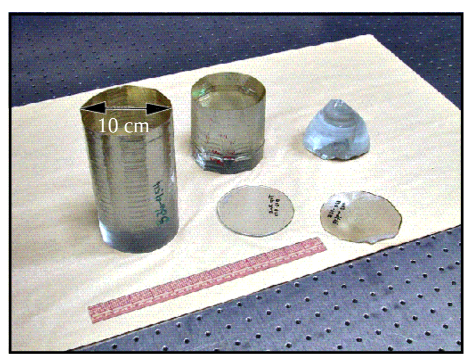
Using the 9-disk prototype heat-capacity laser described above, we performed a series of target interaction experiments. Metal coupons were irradiated by the high-energy laser beam. During these tests, the heat-capacity laser was operated at 3 Hz with energy of 650 J per pulse. The irradiation pulse has a temporal envelope of 300 to 400 microseconds and consists of several relaxation-oscillation spikes with peak intensities near MW/cm^2. The laser beam was configured to a 6 × 6.5 mm rectangular spot onto the target. To guide future target interaction experiments, we continue to develop numerical models to simulate the material removal process using hydrodynamics codes to model the vaporization and material ejection process.



The photo above shows preliminary material removal tests made with the 9-disk module. The protective window transmission had dropped to 50% by the end of this initial run due to molten aluminum deposition. In parallel with laser amplifier activation, work on the adaptive resonator is also making good progress. Components for the adaptive resonator, such as deformable mirror (DM), DM control electronics, and laser diagnostics sensor packages, have been assembled, and characterization tests are under way. Full-power operation of the 9-slab amplifier with the adaptive resonator is expected early 2001.



The development of a diode-pumped Nd:GGG heat-capacity amplifier testbed is proceeding in parallel. We have made significant progress toward the growth of high-quality Nd:GGG boules. Litton Airtron SYNOPTICS is now routinely growing 10 to 15 cm of Nd:GGG with high optical quality. We have also completed the design and testing of a new SiMM (silicon microchannel monolithic) heatsink package for high-power laser-diode arrays and successfully demonstrated output irradiance of 1 kW/cm^2 from a 10-bar diode array, as required. Using a large-area diode array as pumping source, we completed emission cross-section and thermal deposition measurement on Nd:GGG. It appears that Nd:GGG will provide the higher extraction efficiency and fracture strength needed for a 500-J, 100- to 250-kW average power heat-capacity laser system.



(Brent Dane)

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